Resistive wall wake field and extraction jitter in the ILC damping ring

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Overview

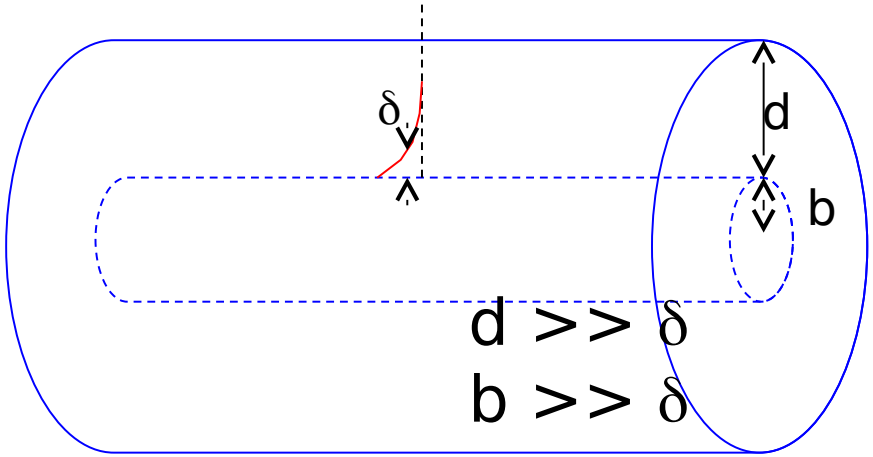
- A study of how the extraction jitter of a beam is affected by the wake field of freshly injected bunches:
  - Wake function for finite wall thickness
  - Dynamics of bunches coupled by wake fields
  - Injection offsets and extraction jitter

Resistive Wall Wake Function

- There is a widely used formula for the transverse wake function:

$$W_1(z) = -2/(\pi b^3)\sqrt{(c/\sigma z)}L$$

  - b = beam pipe radius
  - σ = wall conductivity
  - z = bunch spacing

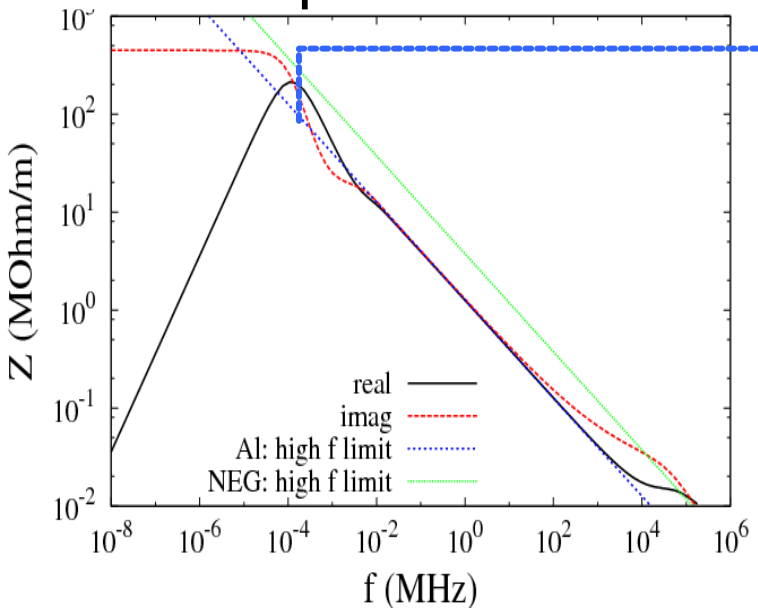


- This assumes infinitely an thick wall, and a very small skin depth. This is true only at high frequencies.

Finite Wall Wake Function

- Impedance peaks when the half wavelength in the wall is equal to the thickness.

Impedance



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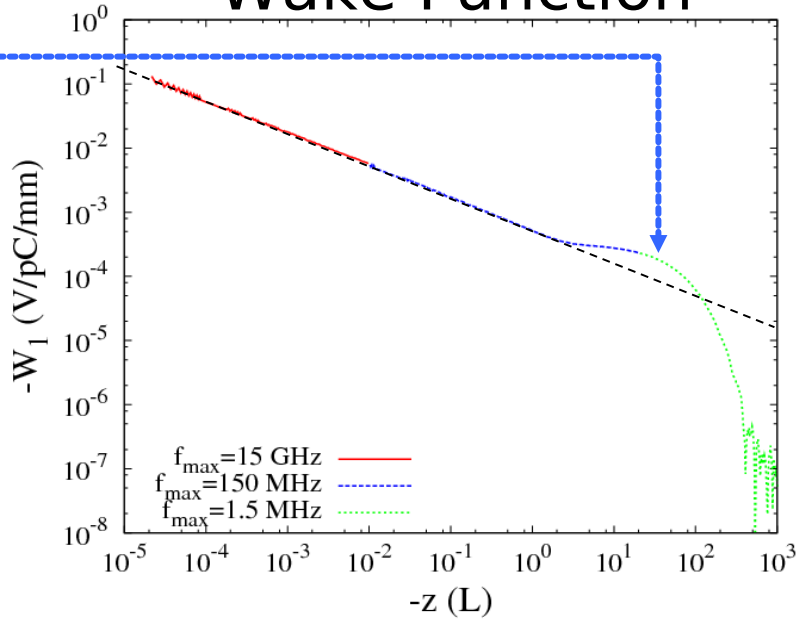
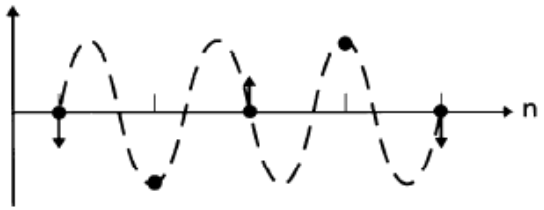
Wake Function

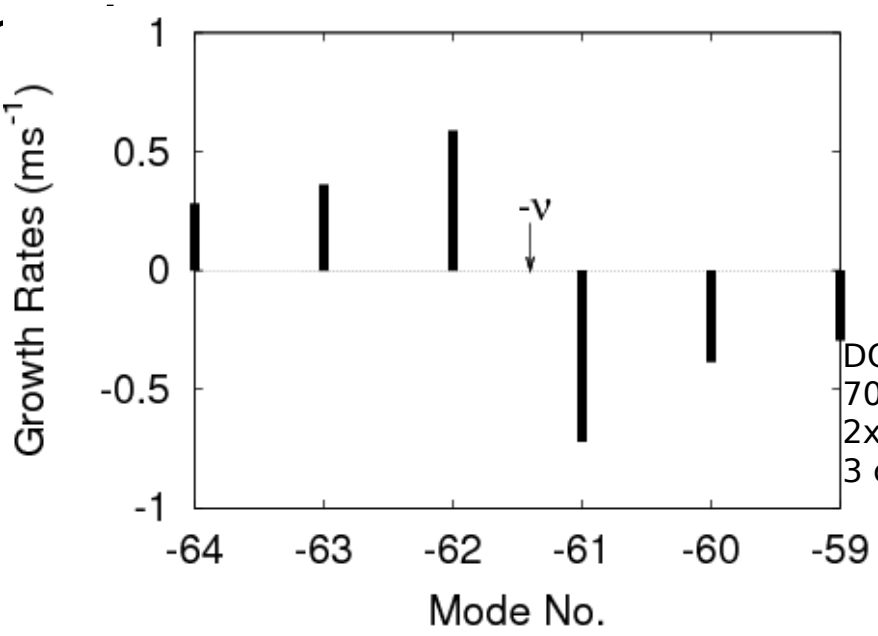


- This causes the wake function to increase at a corresponding distance which could affect the jitter.

Coupled Bunch Instabilities

- There is a standard model for bunches coupled by resistive wall wake field.
- The eigen-modes of bunch displacements are just the Fourier m

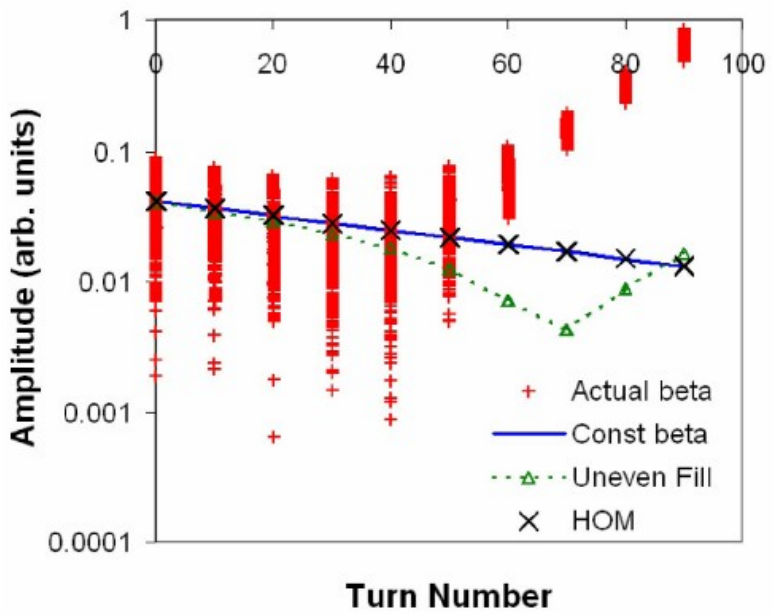




- The growth rate of each mode can also be solved analytically.

Lattice causes mode mixing

- The standard model assumed uniform focusing.
- The actual lattice disturbs the symmetry. Then the eigen-modes are not exactly Fourier.

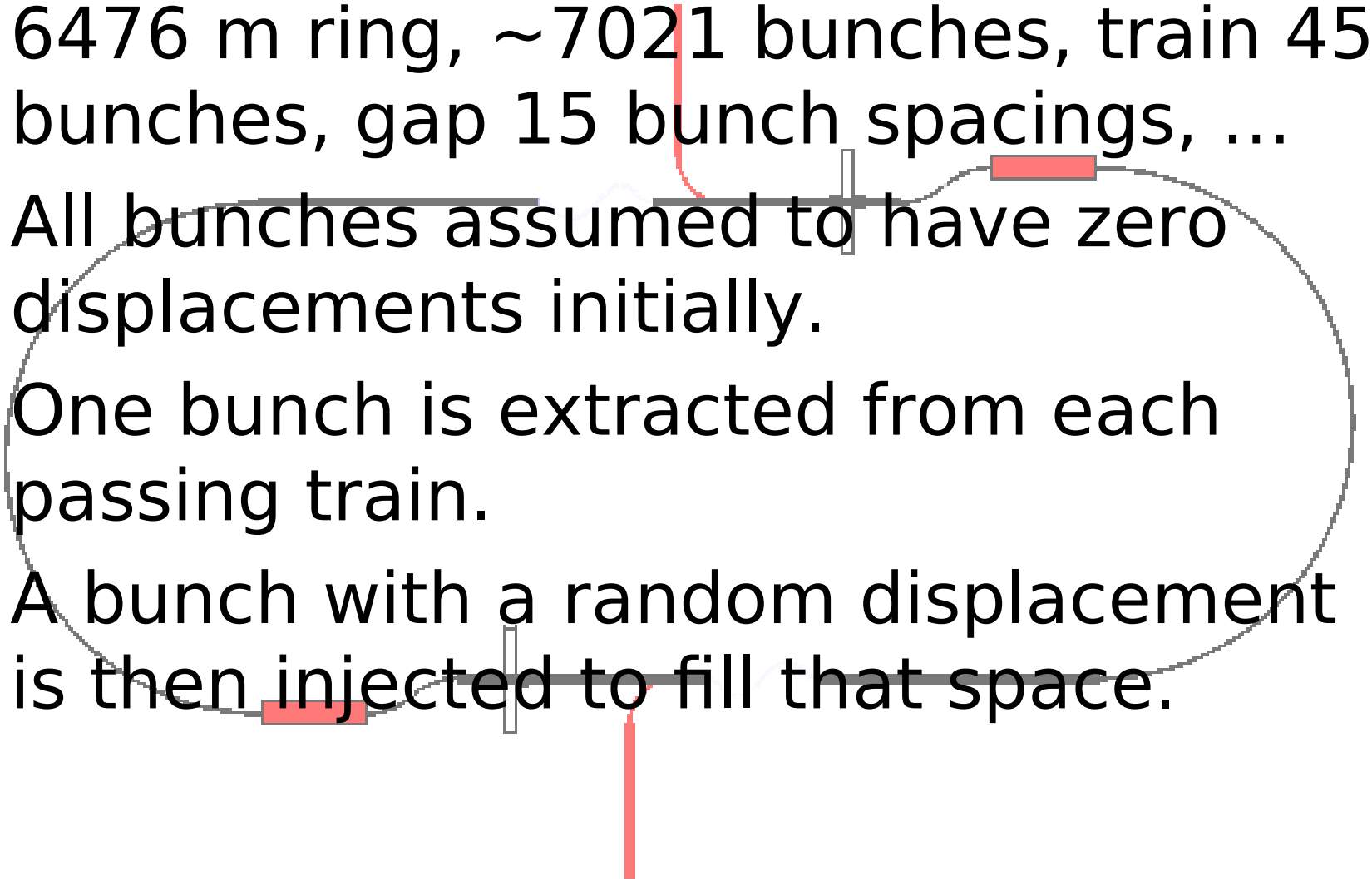


Hock and Wolski, Phys Rev ST AB (2007)

- Fourier modes that grow can mix into those that decay, and cause them to grow – relevant to extraction jitter.

Injection and Extraction

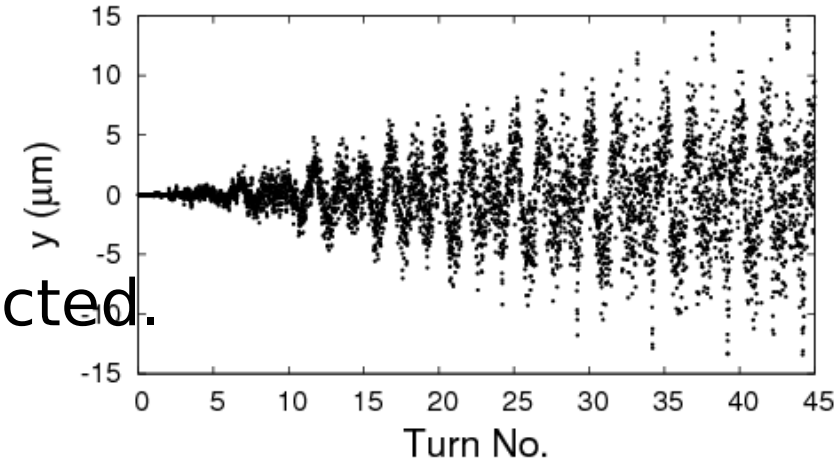
- 6476 m ring, ~7021 bunches, train 45 bunches, gap 15 bunch spacings, ...
- All bunches assumed to have zero displacements initially.
- One bunch is extracted from each passing train.
- A bunch with a random displacement is then injected to fill that space.



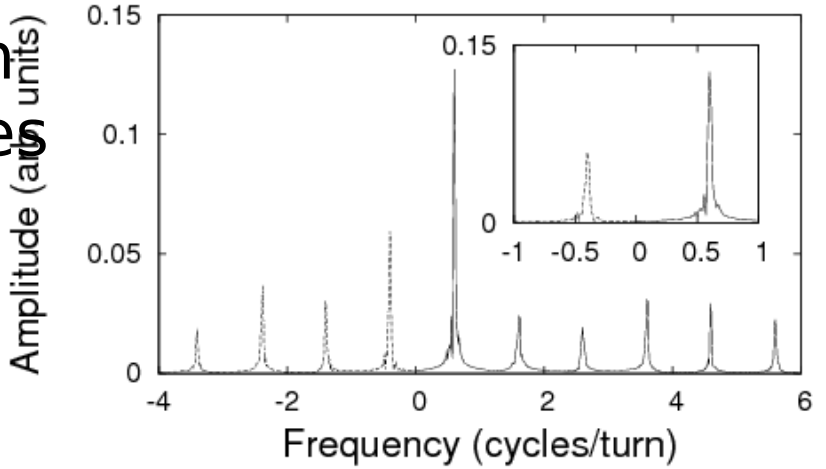
Extraction Jitter

The jitter shows clear modulation.

This is unexpected, because the bunches have been randomly injected.



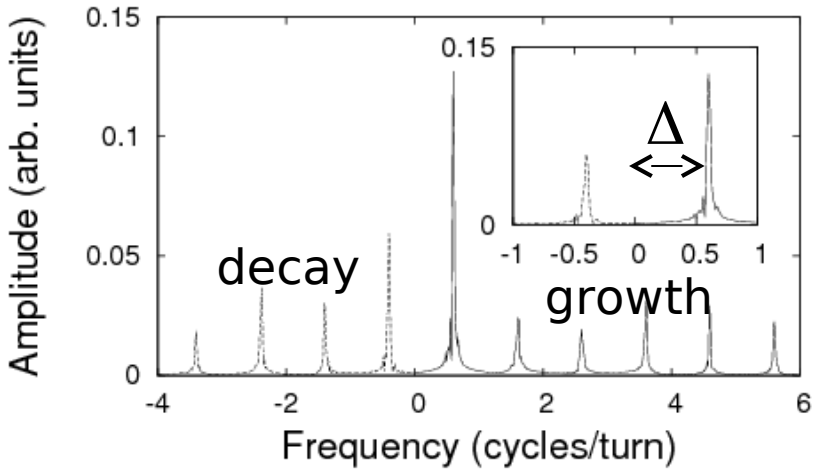
The distinct peaks in the spectrum reveals that the extracted bunches strongly correlated.



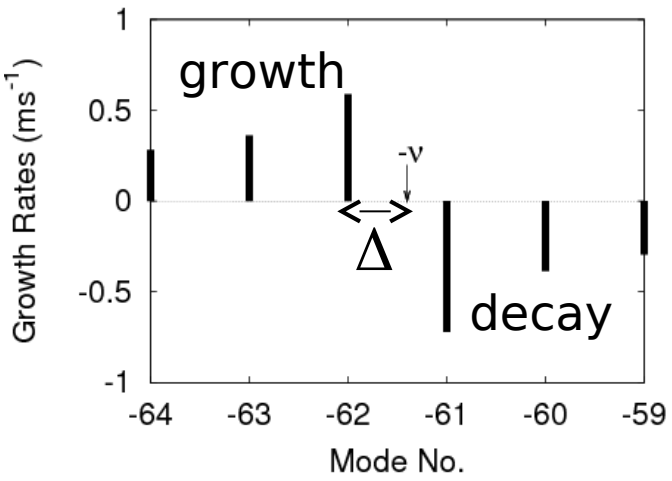
Jitter and Fourier modes

The peak frequencies are exactly right if the jitter modulatio
is attributed to the Fourier modes.

Actual lattice



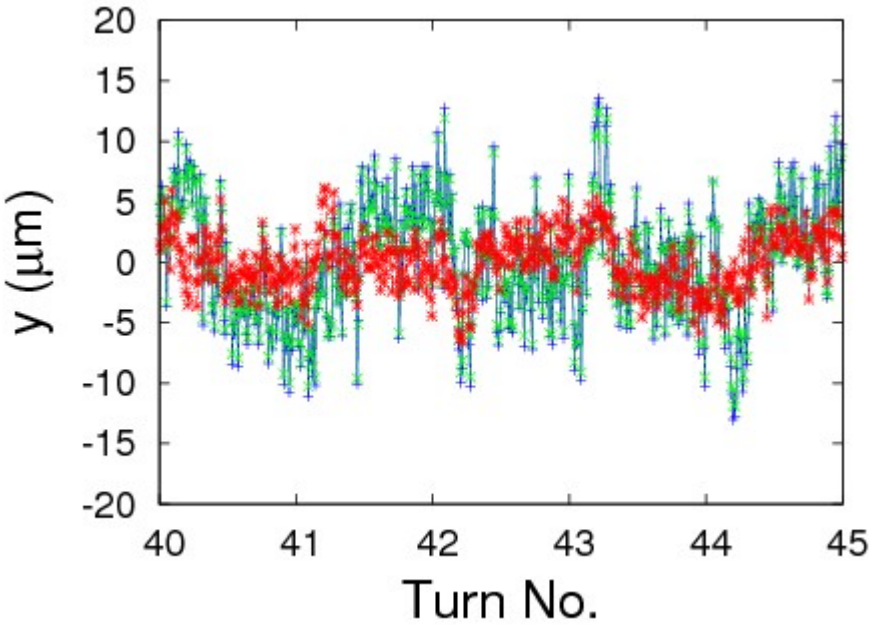
Uniform focusing

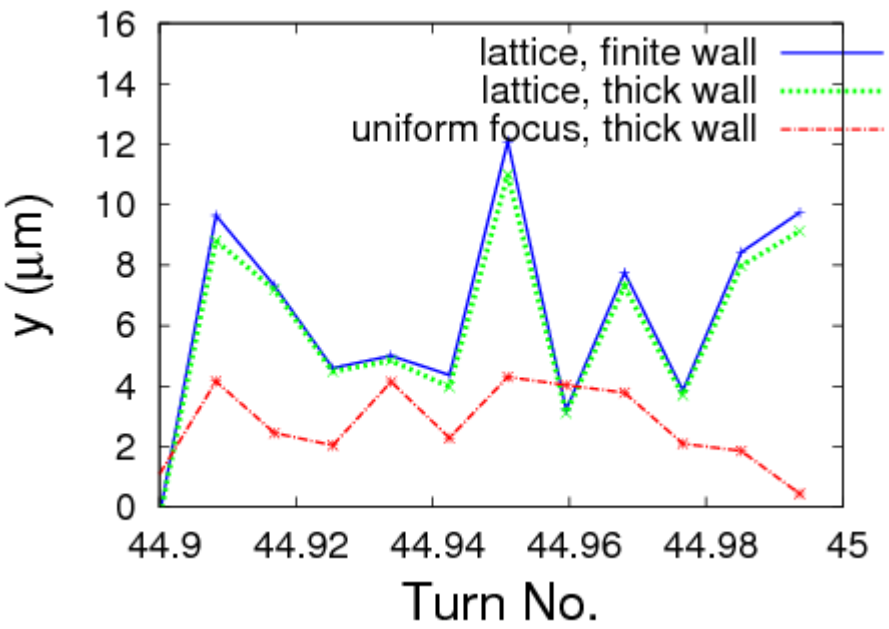


eaks from “decay” modes are as high as those from growth
odes. This may be explained by mode mixing due to the lat

ow important are the lattice and the finite wa

It would be much easier if we can assume constant focusing strength and thick wall as analytic formulae exist.





lattice is important as it doubles the jitter. The finite wall h maller effect, increasing the jitter by a few percent.

Conclusion

- The finite wall wake function peaks at a distance that is directly related to wall thickness.
- If the wall is thinner, wake forces from nearby bunches would be stronger. Then jitter would increase.
- Jitter in the extracted bunches oscillates with a unique frequency determined by the dominant mode.
- The structure of the lattice has a significant impact on the jitter.